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American Journal of Neuroradiology: What Is
Their Impact?**

J.H. Huntley, J. Pakpoor and D.M. Yousem

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The Top 20 Most Prolific Authors in the *American Journal of Neuroradiology*: What Is Their Impact?

J.H. Huntley, J. Pakpoor, and D.M. Yousem

ABSTRACT

BACKGROUND AND PURPOSE: Many articles that are relevant to patient care but published in radiology journals may escape notice by clinicians. We sought to determine how often the 20 most prolific *American Journal of Neuroradiology* (AJNR) authors from 2013 to 2017 published in clinical journals and the extent to which their articles were disseminated into the clinical literature.

MATERIALS AND METHODS: We counted all authors' first- or senior-authored articles in the AJNR from 2013 to 2017 to identify the 20 most prolific authors in AJNR. We searched for these 20 authors' total articles from 2013 to 2017 to determine which were published in radiology or clinical journals and the number of citations received from radiology and clinical journals. Authors were sorted into quartiles according to these metrics, and other descriptive statistics were performed.

RESULTS: The top 20 AJNR authors contributed to 1463 articles during 5 years, including 711 (48.6%) in radiology and 752 (51.4%) in clinical journals. These articles were cited 15,857 times, including 4659 (29.3%) by articles in radiology journals. The more prolific authors published in clinical journals more often (Spearman $\rho = 0.65$, $P = .002$) and were cited more ($\rho = 0.42$, $P = .07$). Articles published in clinical journals were cited more often (mean, 12.3 clinical, 9.3 radiology general versus 8.7 in AJNR), and whether published in radiology or clinical journals, they were cited more frequently by clinical journals.

CONCLUSIONS: Regardless of where it is published, radiology research is disseminating into the clinical realm. Radiology articles published in clinical journals are cited more often than those published in radiology journals.

ABBREVIATIONS: AJNR = *American Journal of Neuroradiology*

The Impact Factors of many radiology journals have increased during the past decade, especially among cardiac imaging and neuroradiology journals.¹ Because of this growth, researchers in radiology may think that publishing their best material in radiology journals is sufficient to reach the wider medical community. A possible drawback of publishing one's articles solely in the radiology literature, however, is that the journals may be outside the routine purview of referring clinicians not in academia and so may have limited influence in broader patient care settings.

For example, how would a private practice general practitioner learn about the appropriateness criteria for MR neurography published in the *American Journal of Neuroradiology* (AJNR)? Such an article may totally escape notice by nonradiologists.

Nonetheless, its message is actually more apropos to the clinical literature. When radiologists exclusively submit articles to their own journals, could they be reducing the impact of their work? A better method may be for radiology researchers to consider whether their work is more relevant to radiologists or nonradiologists and to publish their work in an appropriate journal.

Because neuroradiology is one of the fastest growing fields in imaging science, we sought to evaluate the publishing characteristics of the top 20 contributors to the AJNR, as a sample from one of the most popular clinically focused journals of the specialty. We set out to answer the following questions: 1) To what extent are these neuroradiology authors publishing articles only in radiology journals? 2) Are these articles in radiology journals being cited only by radiologists in radiology journals, or do they disseminate into the clinical literature? 3) Are radiology articles published in clinical journals cited more than those published in radiology journals? 4) How, if at all, do the publishing characteristics of the more prolific of these top 20 authors (ie, the ultraprolific) differ from those of the less prolific in the AJNR top 20? and 5) How do the top 20 authors differ from the next 20 AJNR authors (numbers 21–40) in terms of education/training, funding, and country of origin?

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Table 1: The top 20 AJNR authors sorted into quartiles according to 3 metrics^a

	≥75% (No.) (%)	50%–74% (No.) (%)	25%–49% (No.) (%)	<25% (No.) (%)
Articles published in radiology journals	6 (30)	7 (35)	7 (35)	0 (0)
First or senior author				
All articles (radiology and nonradiology)	1 (5)	12 (60)	6 (30)	1 (5)
Articles in radiology journals	5 (25)	12 (60)	3 (15)	0 (0)
Articles in nonradiology journals	0 (0)	8 (40)	8 (40)	4 (20)
Articles in <i>AJNR</i>	11 (55)	6 (30)	3 (15)	0 (0)
Cited by articles published in radiology journals				
All articles (radiology and nonradiology)	0 (0)	2 (10)	12 (60)	6 (30)
Articles in radiology journals	0 (0)	7 (35)	12 (60)	1 (5)
Articles in nonradiology journals	0 (0)	1 (5)	6 (30)	13 (65)
Articles in <i>AJNR</i>	1 (5)	5 (25)	13 (65)	1 (5)

^a The top 20 authors were sorted into 4 quartiles (≥75%, 50%–74%, 25%–49%, <25%) based on 3 metrics: the percentage of their articles that appeared in radiology journals, the percentage of their articles for which they were first or senior author, and the percentage of citations they received from articles in radiology journals. We determined the latter 2 metrics using all of the top 20 authors' articles, only their articles in radiology journals, only their articles in nonradiology journals, and only their articles in *AJNR*.

MATERIALS AND METHODS

This study did not comprise human subject research and therefore did not require institutional review board approval.

Data Collection

We extracted author information from all articles published in the *AJNR* (www.ajnr.org) between January 1, 2013, and December 31, 2017. Only original research articles (including clinical trials) and review articles were included in this study. We then totaled each author's first- and senior-authored publications in *AJNR* to determine the top 20 most prolific first/senior *AJNR* authors. Google searches of author names were performed to establish each author's primary institution, education/training (MD versus PhD versus MD, PhD), and country of origin (United States versus non-United States). We also determined the next 20 (numbers 21–40) *AJNR* authors and extracted the same data for them as well.

Next, we used PubMed (www.pubmed.gov) to search the MEDLINE data base for all articles published by these 20 authors in any journal between January 1, 2013, and December 31, 2017. For each article, we extracted the complete author list, year of publication, and publishing journal. For the articles in the *AJNR* from both the top 20 authors and authors 21–40, we also recorded whether each study was funded by the US government, funded by an entity other than the US government, or not funded at all. We then determined how many of these articles were published in a radiology (diagnostic or interventional) or clinical/nonradiology journal and whether the top 20 *AJNR* authors in question were in the first, last, or middle position of the author list. Journals on the Scimago Journal and Country Rank Web site (scimagojr.com) under the Radiology, Nuclear Medicine, and Imaging categories (<https://www.scimagojr.com/journalrank.php>) that focused primarily on radiology and imaging topics were considered to be radiology journals for analysis purposes.

On April 4, 2018, we used the Web of Science² to identify the citation counts of articles authored by the top 20 *AJNR* contributors and determined whether the citing articles were published in a radiology or nonradiology journal. In instances in which an article was not available on Web of Science, Google Scholar was used instead (91/1463, 6.2% of articles). The Scopus citations data base³ was queried to extract self-citation data for each of the top 20

AJNR authors as well as the h-index of each of the top 20 *AJNR* authors and *AJNR* authors 21–40.

In instances in which authors had similar names or an author used differing attributions (eg, middle initial or an accented letter), we considered the topic and field of the article, the publishing journal, and the author's institution to determine the author identity and remove duplicates when applicable.

Data Analysis

Descriptive statistics were performed using R, Version 3.4.4⁴ and Excel 2016 (Microsoft, Redmond, Washington). Spearman rank correlation tests were performed when examining the relationship of 2 variables, and Mann-Whitney *U* tests were used when determining whether 2 samples differed significantly. All tests were performed at 95% confidence ($\alpha = .05$).

We sorted individual authors into sets of quartiles (≥75%, 50%–74%, 25%–49%, <25%) according to 3 separate metrics based on their published articles: 1) the proportion of their articles published in radiology journals, 2) the proportion of citations their articles received from articles in radiology journals, and 3) the proportion of their articles in which they were the first or senior author. For each author, we calculated the second and third metrics for the following: 1) all articles, 2) articles published in radiology journals, 3) articles published in nonradiology journals, and 4) articles published in the *AJNR* (Table 1). When analyzing publications of individual authors, articles in which >1 of the top 20 authors appeared on the author list were included in each author's respective set of publications (ie, if 2 of the top 20 authors were authors on the same article, that article would be included in analyses of both authors).

We also evaluated how the more prolific top 20 authors compared with the less prolific top 20 authors. In 1 analysis, we ran a correlation test between each author's total number of published articles and the average number of times their articles were cited. In another analysis, we performed a correlation test between each author's total number of published articles and the percentage of his or her articles published in clinical (nonradiology) journals.

Last, we calculated the following 5 values for all 20 authors collectively: 1) the average number of citations each article received; 2) the average number of citations from articles in radiology journals per article; 3) among articles published in radiology journals, the percentage of citations from articles also in radiology journals; 4) among articles published in *AJNR*, the percentage of citations from articles in radiology journals; and 5) among articles published in nonradiology journals, the percentage of citations from articles in radiology journals.

Last, we calculated the following 5 values for all 20 authors collectively: 1) the average number of citations each article received; 2) the average number of citations from articles in radiology journals per article; 3) among articles published in radiology journals, the percentage of citations from articles also in radiology journals; 4) among articles published in *AJNR*, the percentage of citations from articles in radiology journals; and 5) among articles published in nonradiology journals, the percentage of citations from articles in radiology journals.

RESULTS

Descriptive Statistics

The top 20 authors published 218 unique articles in *AJNR* between January 1, 2013, and December 31, 2017 as first or senior

authors, occupying 252 first or last author positions for an average of 2.52 articles per author per year (total 5-year range, 8–30). They represented about 0.8% of all *AJNR* authors yet occupied 6.8% of first or senior author positions of all *AJNR* articles during that time. The top 20 authors included contributors from the Mayo Clinic (4 authors), Duke University (2 authors), Stanford University (2 authors), and 12 other institutions (Table 2). Of the top 20 authors, 17 had an MD degree only (or equivalent in their country), 1 had a PhD degree only, and 2 had MD, PhDs. Thirteen (65%) of these authors had a primary affiliation with an institution in the United States. The next 20 authors (numbers 21–40 in the *AJNR*), in comparison, included more authors with a PhD degree. Included in this group were 13 authors with an MD only, 1 with a PhD only, and 6 with both an MD and PhD. Twelve (60%) of this group of authors were primarily affiliated with an institution in the United States.

Top 20 Authors' Articles in All (Radiology and Nonradiology/Clinical) Journals

In all journals from 2013 to 2017, the top 20 authors contributed to 1463 unique original investigations, including clinical trials, or reviews (occupying 1724 authorship positions), with 711 (48.6%) in radiology journals and 752 (51.4%) in nonradiology journals. These articles were cited by 15,857 articles in total (mean citations per article, 10.8; median, 4), 4659 (29.4%) of which were in radi-

ology journals and 11,198 (70.6%) in nonradiology journals. Articles in clinical journals were cited an average of 12.3 times per article. The distribution of citations is highly skewed to the right (Pearson skewness coefficient = 0.49). More than half (52.8%) of articles were cited ≤ 4 times, and those cited ≤ 40 times accounted for $>95\%$ of all published articles (Figure). One article was cited 1283 times, accounting for 8.1% of all citations. While review articles accounted for only 19.3% (280/1463) of articles, they were cited significantly more, on average, than original investigations when clinical trials were not included (13.5 versus 8.0, $P < .001$). Only 124 articles detailing clinical trials were included in the dataset. These articles were cited an average of 29.1 times each, largely due to a select few articles being very highly cited. Nevertheless, clinical trial articles did not receive a significantly different number of citations, on average, than review articles ($P = .85$). On the other hand, clinical trial articles did receive a significantly higher number of citations than non-review, non-clinical trial original investigations ($P < .001$).

There was a positive correlation between the total number of articles an author published and the average number of times their articles were cited (Spearman $\rho = 0.42$, $P = .07$). More prolific authors were significantly more likely to publish in non-radiology journals ($\rho = 0.65$, $P = .002$) and to publish a smaller proportion of their articles in *AJNR* ($\rho = -0.86$, $P < .001$). The top 10 *AJNR* authors had an average h-index of 37.5 ± 14.3 (range, 43), whereas authors 11–20 had an average h-index of 32.4 ± 18.0 (range, 48) ($P = .43$). The top 20 *AJNR* authors did not have a significantly different average h-index than *AJNR* authors 21–40 (mean, 35.0 ± 16.1 versus mean, 34.2 ± 17.7) ($P = .79$). Only 8.3% of the citations from the top 20 authors were self-citations.

Six of the top 20 authors (30%) published at least 75% of their articles in radiology journals, 7 (35%) published between 50% and 74% of their articles in radiology journals, and 7 (35%) published between 25% and 49% of their articles in radiology journals. No author published $<25\%$ of their articles in radiology journals (Table 1).

When considering articles that the top 20 authors published in all journals (radiology and nonradiology), no author received $\geq 75\%$ of their citations from articles in radiology journals (ie, at least 25% of the articles that cited them were in nonradiology journals). Only 2 authors (10%) received 50%–74% of their cita-

tions from articles in radiology journals, with most (12/20, 60%) receiving 25%–49% of their citations from articles in radiology journals. The remainder (6/20, 30%) received $<25\%$ of their citations from articles in radiology journals (Table 1).

Only 1 top 20 author (5%) was first or senior author for $\geq 75\%$ of his or her articles. Most authors (12/20, 60%) were first or senior author for 50%–74% of their articles, while nearly all the rest (6/20, 30%) were first or senior author for 25%–49% of their articles. One author (5%) was the first or senior author for $<25\%$ of his or her articles (Table 1).

Table 2: Primary affiliations of the top 20 *AJNR* authors

Institution	No. of Authors
Mayo Clinic	4
Duke University	2
Stanford University	2
George Washington University	1
Harvard University	1
Hofstra University	1
Johns Hopkins University	1
Seoul National University	1
University at Buffalo	1
University of Amsterdam	1
University of Montréal	1
University of Paris-Sud	1
University of Reims Champagne-Ardenne	1
University of Toronto	1
Uppsala University	1

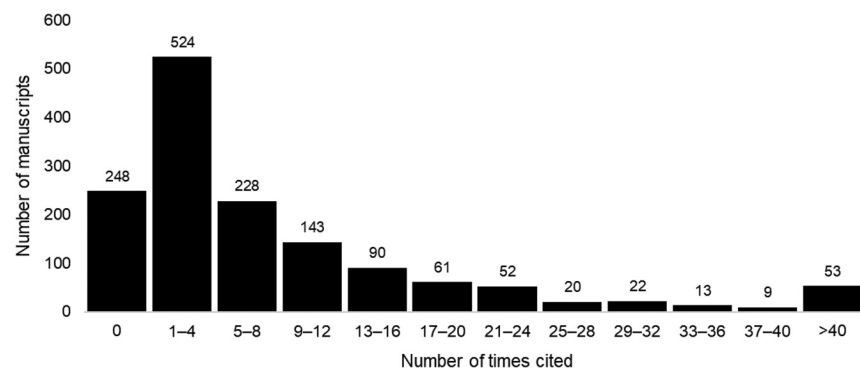


FIGURE. A histogram of how many times all articles from the top 20 *AJNR* authors were cited. Most (52.8%) articles were cited ≤ 4 times, and 17.0% were not cited at all. Articles that were cited >40 times are combined into a single bin.

Top 20 Authors' Articles in Radiology Journals

The 711 articles published in radiology journals were cited 6577 times in total (mean citations per article, 9.3). When we considered only his or her articles published in radiology journals, no author (0%) received at least 75% of their citations from articles in radiology journals, 7 (35%) received between 50% and 74% of their citations from articles in radiology journals, 12 (60%) received between 25% and 49% of their citations from articles in radiology journals, and only 1 (5%) received <25% of their citations from articles in radiology journals (Table 1).

Most interesting, articles published in radiology journals received slightly fewer citations, on average, than articles published in clinical, nonradiology journals (9.3 versus 12.3, $P = .16$), albeit not to a significant degree.

Top 20 Authors' Articles in AJNR

The top 20 AJNR authors contributed as first, middle, or senior author to a total of 272 unique original investigations or reviews in AJNR during the study period. These articles were cited a total of 2364 times (mean citations per article, 8.7). When we considered only the articles published in AJNR, 1 author (5%) received at least 75% of his or her citations from articles in radiology journals, 5 (25%) received between 50% and 74% of their citations from articles in radiology journals, 13 (65%) received between 25% and 49% of their citations from articles in radiology journals, and only 1 (5%) received <25% of his or her citations from articles in radiology journals (Table 1).

When we considered studies from the top 20 authors, roughly one-third (84/272, 30.9%) recorded receiving funding only by the US government (28/272, 10.3%), by some entity other than the US government (46/272, 16.9%), or by both the US government and some other entity (10/272, 3.7%). Funded studies of the top 20 authors received significantly more citations than unfunded studies (11.5 versus 7.4, $P < .001$). In comparison, a higher percentage of studies from AJNR authors 21–40 received funding; of these 34.0% (66/194) of funded studies, 15.5% (30/194) were funded only by the US government; 12.4% (24/194), only by an entity other than the US government; and 6.2% (12/194), by both the US government and some other entity.

Additional Analyses for All Top 20 Authors

The top 20 AJNR authors received an average of 10.8 (median, 4) citations per article during the study period. Of the 10.8 citations per article, only 3.2 (29.4%) were from articles in radiology journals. When we considered only the articles from these authors published in a radiology journal, however, 43.0% of the citations received were from articles also in radiology journals. Articles that were published in nonradiology journals received only 19.7% of their citations from articles published in radiology journals. For articles published in AJNR, 41.2% of the citations received were from articles in radiology journals. In summary, most of the citations that the top 20 AJNR authors received for their publications in any journal, in radiology journals, in nonradiology journals, and in the AJNR were from articles in clinical, nonradiology journals.

DISCUSSION

In this study, we identified several interesting features about the publishing characteristics of the top 20 most prolific authors in AJNR from 2013 to 2017. Overall, these authors averaged between 2 and 3 articles published in AJNR per year as first or senior author, with the most prolific author publishing nearly 4 times as many articles as the twentieth most prolific author (30 articles versus 8 articles). When we considered all articles written by these authors, nearly half (48.6%) were published in radiology journals and half (51.4%) in nonradiology journals. More than half of the authors, however, published more than half of their articles in radiology journals and received less than half of their citations from articles in radiology journals. Finally, we found that most of these top authors were first or senior authors on more than half of their articles published in all journals (radiology and nonradiology).

One of our most interesting analyses revealed that when the top 20 authors published in radiology journals, they were cited by articles in radiology journals more than twice as often as when they published in nonradiology journals (43.0% versus 19.7%). This disparity in citations between publishing in radiology and nonradiology journals may suggest that radiology researchers who produce articles with high clinical relevance should be publishing in nonradiology journals if they want to capture the attention of clinicians more broadly. We note, however, that all articles in radiology journals, clinical (nonradiology) journals, and AJNR specifically were cited more often by articles in clinical journals than in radiology journals. Therefore, even if radiology researchers continue to publish exclusively or primarily in radiology journals, their message will still be distributed to clinicians—though perhaps not as widely as if their work appeared in a nonradiology journal. In any case, the radiologist's message is getting out.

Comparing the publishing habits of the more prolific top 20 AJNR authors with those of the less prolific top 20 authors showed that more prolific authors are cited more often on average ($\rho = 0.42$, $P = .07$). This finding may simply result from publishing more often. If authors publish more often, they are more likely to produce a "hit" that boosts the average number of times they are cited.^{5,6} While these data indicate that the more prolific authors among the top 20 are cited more often than the less prolific ones, our h-index analyses suggest that the top 20 as a group are roughly equal to authors 21–40 on this metric. Thus, there may be 2 broad categories of authors at play: One is very prolific overall and, as expected, publishes a smaller proportion of their articles in AJNR, and the other is less prolific overall and publishes a larger proportion of their articles in AJNR. Authors in these 2 categories seem to be interspersed throughout the top 40 authorship ranks in AJNR so that the authors with the highest number of AJNR publications are not simply ultraprolific researchers who publish a small proportion of their articles in AJNR, nor are they only researchers who publish a large proportion of their articles in AJNR—there is a mix of the 2.

We also found that authors who are more prolific overall published a significantly higher proportion of their articles outside of radiology journals ($\rho = 0.65$, $P = .002$). One explanation for this finding may be that when the top neuroradiology researchers publish outside of radiology, their work tends to appear in higher

impact journals.⁷ If the most proliferative authors we analyzed publish in high-impact nonradiology journals more commonly than the less proliferative authors, they would likely receive more citations on average. While we did not assess the Impact Factors of the journals in which the top 20 *AJNR* authors published, we did find that articles published in nonradiology journals were cited slightly more often overall than articles published in radiology journals and in the *AJNR* specifically (12.3 versus 9.3 versus 8.7).

Radiology is becoming a more interdisciplinary field. A study published in 2006 compared articles in 3 large radiology journals during 2 periods (1992–1993 and 2002–2003), finding that primary authors were less likely to be radiologists.⁸ Our findings in this study corroborate this notion of increasing diversification in radiology: The top 20 *AJNR* authors published nearly half of their articles from 2013 to 2017 in radiology journals, leaving the other half distributed primarily across clinical journals. Another study that analyzed where radiologists publish similarly found that roughly one-third of articles with a radiologist as a first author were published in nonradiology journals.⁷ If this publishing pattern is consistent among radiology researchers in general, there is a sizable body of radiology literature that appears outside radiology journals. In fact, Lehman et al (2014)⁹ found that nearly 90% of articles about intracranial imaging of uncommon diseases appeared in clinical publications. This phenomenon is not unique to radiology; researchers publishing in journals outside their “core” field have been described in several other fields as well, including occupational therapy,¹⁰ medical informatics,¹¹ family medicine,¹² and nephrology.¹³ This evidence all points to the same conclusion: Because radiology research is increasingly being published in journals that aim to reach the broader medical community, radiologists may wish to also regularly include nonradiology journals in their reading.

Several limiting factors may have influenced our findings. First, articles published earlier in the study period had more time to be cited by other authors,¹⁴ but this applied to all 20 top authors and we stopped looking at articles published after December 31, 2017. Some articles were also published less than a year before the data analysis. While this likely resulted in articles being cited less often than if we had chosen an earlier timeframe, we expect our other findings to be largely unaffected. Another study that analyzed citation counts of immunology and surgical journals found that a median of 17.6% of articles in immunology journals were uncited and a median of 32.8% of articles in surgical journals were uncited.¹⁵ In comparison, 17.0% of the articles we analyzed were uncited. These authors also found a median citation count for original articles (3 for immunology articles and 1 for surgical articles) that is comparable with what we found (4 for all articles). We also did not adjust our results for self-citation. We did, however, determine that the self-citation rate among the top 20 authors was roughly 8%—a relatively low rate¹⁶ of self-citation that is unlikely to significantly impact our conclusions. The type of article that each author published most frequently may have also affected our results. Because reviews tend to be cited more often than original investigations¹⁷ (in our data, 13.5 versus 8.0, $P < .001$), authors who write more reviews would likely receive more citations than authors who do not write as many.

CONCLUSIONS

The top 20 *AJNR* authors publish nearly equally in radiology and nonradiology journals. Their work, however, is cited more commonly by articles in clinical journals than by articles in radiology journals, no matter where that original article was published. A radiology article published in a clinical journal tends to have more citations than one published in a radiology journal and the *AJNR*. This suggests that dissemination of radiology research in the clinical realm is progressing.

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